

Chapter 8

PORTS

Obtaining adequate port facilities early in any overseas campaign is essential to the efficient flow of troops and materiel into a given Theater of Operations. Port construction, rehabilitation, and repair are of vital importance to the success of any such mission. Securing these facilities is often an initial objective of overseas operations. Host nation agreements granting military use rights are essential to ensure the impact on commercial shipping and local military operations is kept to a minimum.

While the situation dictates the course of action, assault landing facilities are usually used for supply and replenishment in the initial phase of a campaign, followed by LOTS operations, as discussed in Chapter 7. As established port areas are acquired or rehabilitated, beach sites are normally abandoned. Certain areas of operation, however, may require use of beach sites for extended periods of time or even indefinitely, due to the lack of existing facilities, the geography, the terrain, or the enemy situation. The construction of new ports is normally undesirable, as it requires a large amount of labor, materials, and time, and probably would lack the desirable related facilities, such as connecting road and rail networks. Therefore, existing ports are usually targeted for rehabilitation and upgrade. The Engineer mission is to support construction, maintenance, and repair of a wide variety of facilities, both above and below the waterline.

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SCOPE OF PORT OPERATIONS

This chapter is a guide for the construction and rehabilitation of ship unloading and cargo handling facilities in Theater of Operations ports. The coverage includes special problems encountered in port construction and the construction of those supporting structures located in and around the port facility. Based on current trends in the commercial shipping industry, it is anticipated that up to 90 percent of all cargo arriving in future Theaters of Operations will be containerized.

This method of shipping requires dock and road surfaces capable of withstanding severe loads, as well as heavy lift equipment capable of transferring the largest loaded container (8 feet wide, 40 feet long, 67,200 pounds) from

large, oceangoing vessels to shore facilities. These factors should be considered during port planning. The guidelines concerning facilities for handling containerized cargo and container shipping outlined within this chapter represent the most current developments in this industry.

The information provided is also applicable to both nuclear and nonnuclear warfare scenarios. In nuclear scenarios, however, large new ports would almost certainly not be built, and it is unlikely that existing large ports would be rehabilitated because of the excellent interdiction target they would make. The port construction effort in these circumstances would be confined to numerous small ports which would not offer lucrative targets to the enemy.

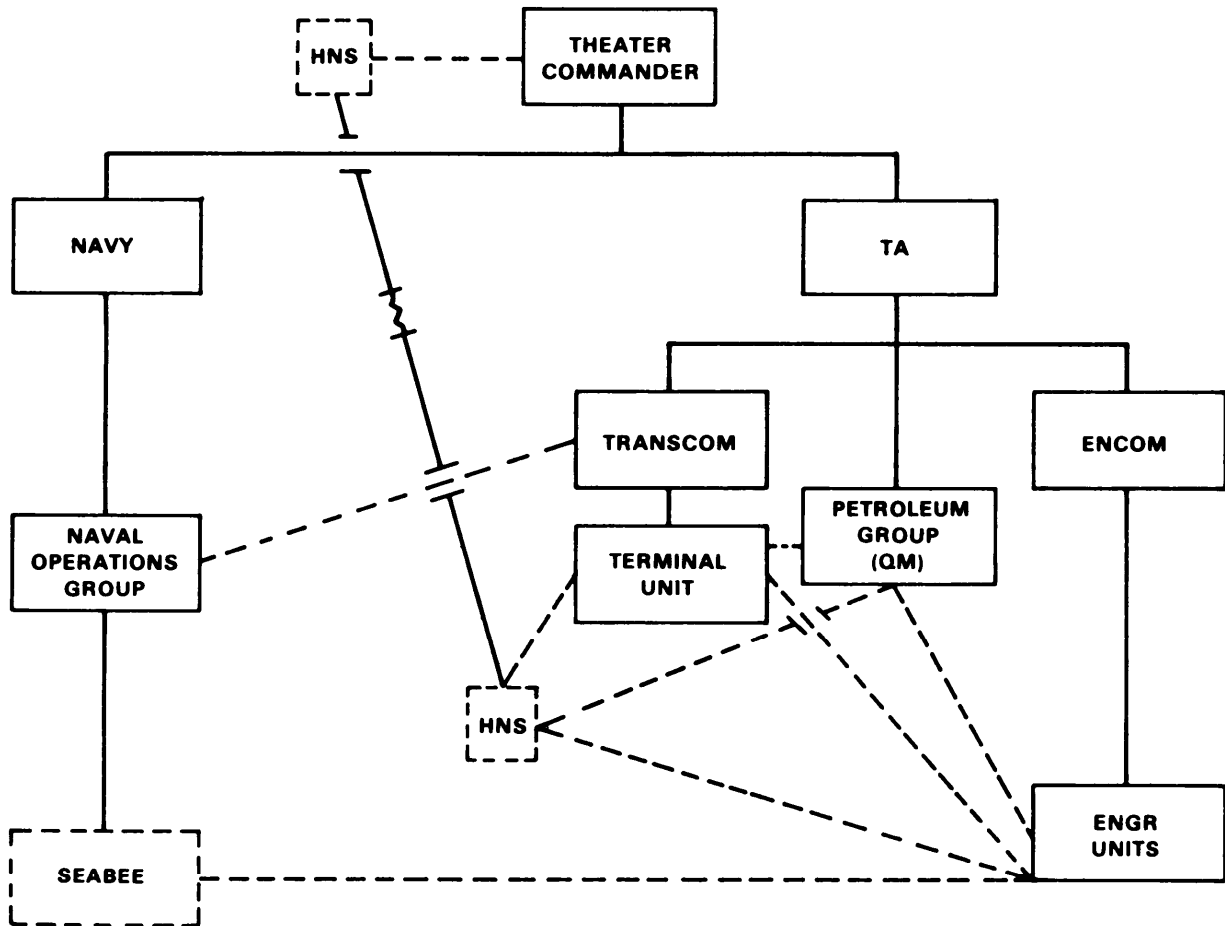
CONSTRUCTION RESPONSIBILITIES

The operation of a port in a Theater of Operations is a large and vital undertaking with many divisions of responsibility between the Navy and the branches of the Army. Basic decisions as to the location of ports, capacity, utilization, wharfage, and storage facilities are made at the Theater and Theater Army (TA) and Transportation Command (TRANSCOM) Headquarters. The responsibilities of the Theater Command, Theater Army Command, and TRANSCOM commander are stated in FM 100-10. The TA Assistant Chief of Staff (ACS), Movements, is responsible for operating ports and furnishing liaison with the Navy, Coast Guard, and other interested military and authorized civilian agencies, both of allied countries and the United States. The ACS, Movements, requests, advises, and makes recommendations concerning the engineer troops employed and the work concerned.

THEATER, THEATER ARMY, AND TRANSCOM RESPONSIBILITIES

The functions of higher echelon command for the construction or rehabilitation of a port include:

- Ž Studies of intelligence reports and all available reconnaissance applying to each port area that is considered for use.
- Ž Tentative determination of the ports or coastal area to be used as a part of overall strategic planning.
- Ž Assignment of the mission of the port.
- Ž Determination of port requirements.
- Ž Tentative decision on the general methods of construction to be used, and determination of engineer units, special equipment, and materials required.



SUBJECT TO AVAILABILITY
 COMMAND

COORDINATION
 COMMAND (LESS INTERMEDIATE CHAIN)

RESPONSIBILITIES		
NAVY	TRANSCOM (TC)	PETROLEUM GROUP (QM)
Major Dredging Major Salvage Operations Offshore Construction	Port Operations Establish Construction Priorities Movement of Freight Out of the Port Area	Operation of POL Pipelines Off-vessel Discharging and Loading of POL
	ENCOM	
	Rehabilitation and Construction of Over Water Facilities, Breakwaters, Storage Areas, Utilities, POL Facilities Fire Fighting Facilities Dredging Minor Salvage Operations Real Estate Functions	

ENGINEER SUPPORT TO PORT CONSTRUCTION/REHABILITATION

ENGINEER UNITS

Engineer units are responsible for port construction and rehabilitation and for coordinating all work with that of any Navy units engaged in harbor clearance and salvage operations, such as the neutralization of mines and underwater obstacles. Engineers perform minor salvage operations, such as clearing obstructions and debris from harbor entrances and improving channels. This does not include large-scale salvaging, which is a Navy responsibility. The majority of tasks will be accomplished by Engineer Port Construction Companies, Combat Heavy Battalions, and specialty teams assigned to the Table of Organization and Equipment (TOE) 5-530 series. In performing their mission of rehabilitation, construction, and maintenance of a port, Army engineers are responsible for—

- Ž Construction and repair of breakwaters, docks, piers, wharves, quays, moles, and landing stages.
- Ž Construction and maintenance of roads in the port area.
- Ž Construction, and major maintenance only, of railway facilities required by the port.
- Ž Construction of storage and marshaling areas required by the port.
- Ž Construction or reconstruction of port utilities including water supply, electric power, and sewerage, if required.
- Ž Construction, and major maintenance only, of tanker unloading facilities, including mooring facilities, submerged pipelines, surface pipelines, and rigid POL tank farms.
- Ž Maintenance and operation of the fire fighting facilities of the port.
- Ž Dredging, except as accomplished by the Navy.
- Ž Debris clearance in the port area.
- Ž Acquisition of buildings, facilities, and other property within the port area for military use.
- Ž Provision of warehouses, depots, quarters for port personnel, and other facilities as required for the operation of the port.
- Ž Continuous study of the port situation and preparation of tentative plans for possible contingencies.
- Ž Requisitioning of the supplies and equipment to carry out the mission.
- Ž Provision of diver support from theater level.
- Ž Liaison with naval units to coordinate construction with harbor clearance activities.
- Ž Recommendation for the assignment of seized areas and facilities within the port area.
- Ž Advising the TRANSCOM Commander and staff on engineering matters connected with the identification, classification, in-transit storage, movement, and distribution of engineer equipment and Class II and IV construction materials.

The engineer unit normally responsible for major port construction or rehabilitation is the engineer construction group. It is organized to include an Engineer Port Construction Company or Companies, Pipeline Construction Support Companies, Combat Heavy Engineer Battalions, Dump Truck Companies, Engineer Construction Support Companies, Dredge Teams, and other units

the mission may require. When several groups are employed together, they are organized as an engineer brigade.

The engineer construction group is a flexible organization, and only becomes operational when working units are assigned or attached to it. The Headquarters and Headquarters Company, Engineer Construction Group, commands and controls three to five Combat Heavy Battalions or their equivalent in assigned or attached troops. When composed of two or three Combat Heavy Battalions and at least one Port Construction Company, the group is capable of typical wharf construction. Pipeline Construction Support Companies, dredges and Dredge Teams, Construction Support Companies, and Dump Truck Companies are added as the mission and scope of work requires.

The Engineering Port Construction Company normally operates as one element of a large-scale, coordinated construction operation under an engineer group, although it can be employed separately on minor projects. Its activities are limited mainly to the construction or major repair of waterfront structures and POL off-loading facilities and anchorages. It is preferable to assign related on-land projects to a Combat Heavy Battalion or other specialized unit, so that the Port Construction Company can handle the specialized waterfront construction. The company is organized for two-shift operation. Its equipment includes crane-shovels with attachments for dredging, excavating, pile driving, and other work; pipeline equipment; hydraulic jacks; air compressors; pumps; tractors; concrete mixers; bridge erection boats; and Landing Craft Mechanized (LCM). It is equipped for light repair or salvage operations on ships or other floating plants.

Engineer divers operate under TOE 5-530 as cellular teams that provide specialized diving support to all theater requirements. As in the LOTS environment, a Control and Support Detachment located at theater level coordinates the efforts of operational teams attached to corps and echelons above corps, in support of port construction missions.

One such operational unit, the Deep Water Diving Team, is allocated to port construction companies on a basis of one team per one to three companies. These teams are capable of two shift operations using SCUBA, lightweight, and deep sea equipment up to a maximum depth of 250 feet. Missions that these teams could expect to perform in support of port construction operations include—

- Ž Light underwater salvage,
- Ž Harbor clearance,
- Ž Underwater pipeline repair/maintenance,
- Ž Fixed bridge construction,
- Ž Port construction, repair, and rehabilitation,
- Ž Ship husbandry,
- Ž Support of LOTS operations.

The Deep Water Diving Team is capable of up to three simultaneous separate operations or one extended diving operation. Some of the equipment peculiar to these cellular teams includes deep sea, lightweight, and SCUBA diving equipment, underwater hydraulic tools, recompression chamber, small watercraft, demolition equipment, and photo gear. Additional equipment and support such as

underwater damage assessment televisions systems, salvage pumps, and diving equipment maintenance support can be obtained through the control and support team or on an as needed basis.

The Lightweight Diving Team is one other operational unit which may support port construction operations. These teams can perform all missions of the Deep Water Teams, with the exception of deep sea and extended operations, and only to a maximum depth of 190 feet. Unlike the Deep Water Team, the Lightweight Team is capable of only two separate diving operations at one time.

Engineer dredge teams of the TOE 5-500 series are assigned to operate organic currter-head pipeline or seagoing hopper dredges. Dredges of other types, when found in ports or waterways, are usually best operated by host nation personnel.

Other units required for engineer service in connection with port construction may include forestry, topographic and intelligence, maintenance, fire fighting, and utility units.

TRANSPORTATION UNITS

Transportation units are responsible for operating the port. The unit coordinates operational activities with the completion of necessary projects, and provides liaison with the Navy and Coast Guard. The transportation unit also performs a continuous study of the needs of the port facilities to ensure the smooth and orderly flow of personnel, supplies, and materiel through the port. The unit staff plans, supervises, and controls freight

movement from the port by rail, motor, and inland water transportation, and under certain conditions, air transport. Finally, the transportation unit is responsible for establishing engineer construction priorities.

QUARTERMASTER UNITS

The quartermaster units have overall responsibility for the operation of petroleum pipeline systems including off-vessel discharging and loading. They coordinate with naval units, engineer units, and transportation units in determining the location of tanker unloading and vessel fueling facilities.

CIVILIAN LABOR

Civilian labor is used to the fullest possible extent in order to reduce the requirements for engineer units or to expedite construction. In the rehabilitation of developed areas, it may be practical to arrange employment of host nation engineers, contractors, superintendents, and the like, with their organizations. These may include a variety of skilled workers. In many undeveloped areas, local businesses have established organizations to employ and supervise labor in agriculture and other pursuits. Such organizations can often provide labor skilled in primitive construction methods. In either case, the plans for employing civilian labor must include adequate consideration of such factors as housing, transportation, local customs, language difficulties, any locally determined complications due to race or religion, and adapting construction plans to the methods and materials to be used. The use of local civilian labor results in savings in mobilization and demobilization costs, and savings due to the local wage scale and standard of living provided in work camps.

PLANNING FACTORS

Wherever possible, port construction efforts in the Theater of Operations are based upon the rehabilitation and/or expansion of existing facilities rather than new construction. Once the decision as to the location of the port has been made at the theater headquarters, the mission is assigned to an appropriate engineer command. The location of the port will be made based upon an analysis of the projected capacity of the facility, the quantity and nature of cargo to be handled, the tactical and strategic situation, and the construction materials and assets available.

Careful planning based upon extensive and detailed reconnaissance is essential to successful port construction. This reconnaissance should begin upon receipt of the mission and continue throughout construction and up to actual occupation. A thorough initial reconnaissance will help planners to estimate logistical requirements by providing data on the physical condition of the port to be seized or occupied.

Based upon this analysis, construction assignments, facilities required, and scheduled target dates for various phases of development are derived and outlined in the operation order. From this information, a construction schedule is formulated. Construction schedules are prepared to show in detail the time plan for all operations in their proper sequence. Equipment hours and man-hours of labor required for each principal operation are then tabulated. The construction schedule is based on—

- Ž Time allowed for completion,
- Ž Available equipment,
- Ž Type of labor available (regular troop units, reserve troop units, newly activated troop units, local contractors, international contractors),

- Ž Delivery of construction materials,
- Ž Local sequence of operations,
- Ž Necessary delays between operations,
- Ž Weather.

After the port has been occupied, planners must carefully and critically examine previous plans in view of the actual physical condition of the port. The impact of proposed changes on logistics and scheduling must be coordinated through engineer, transportation, and command channels. Priorities established in the operation order may have to be modified after construction is undertaken. Planning and scheduling are based on meeting all immediate needs, while ensuring that all work contributes toward the anticipated requirements.

Studies are made to determine the relative value of rehabilitation and construction. These studies compare the value to be gained from specific facilities within a port to the construction effort required. Among other factors, selection of the best ports for further development is determined by the need for dispersion, location of logistical requirements, time and effort required to move construction units, and local availability of materials as well as civilian or prisoner-of-war labor.

Port capacity requirements are estimated by Headquarters, TRANSCOM, or the Theater Army Support Command (TASCOM) ACS, Movements. The engineer usually makes an independent estimate of the capacity of the port under various alternative methods of construction, repair, or rehabilitation. This procedure serves as an aid to determining the most advantageous relative priorities of engineer projects. The capacity estimates of TRANSCOM and TASCOM, however, must govern with respect to military loads. On the

basis of port capacity estimates, the engineer recommends schedules for construction/rehabilitation of port cranes and other facilities, road and railroad construction within the port area, preparation of storage and marshaling areas, and the like. Some considerations in port capacity estimating and planning follow.

WHARF FACILITIES

Rehabilitation and construction priorities, choice of construction materials, and plans of operations for the port are factors which determine the attainment of the greatest capacity from the wharfage with the least expenditure of manpower and materials.

DISCHARGE RATES

Port capacity estimates are based on the discharge rates of ships either at the wharf or in the stream. Priority is given to methods which allow ships to be discharged more quickly. Construction is scheduled in coordination with transportation operations so that construction activities interfere as little as possible with the discharge of ships.

ANCHORAGE AVAILABLE

When sheltered anchorage is available, light-erage operation offers a means of discharging cargo while deep-water wharves are under construction or repair. By conducting light-erage operations while construction and rehabilitation work go forward, continued unloading is possible through the use of the following alternatives:

- Ž The continuous dredging of the deep-water wharf approach channel by using a shallow-draft approach and discharge outside of dredging work areas.
- Ž The use of the shallow-draft parts of the wharf systems while some of the deep-water wharves are under construction.
- Ž Unloading shallow-draft vessels over deep-draft wharves during construction.

Planners may use the basic periods of time such as the two-shift, 20-hour working day, or the days in a month to prepare estimated labor needs extending over a period of time. However, adverse physical conditions peculiar to the location must be considered. For example, severe icing conditions during the winter months, periods of extreme tide range, or severe seasonal winds may have a direct bearing upon construction or rehabilitation work. When heavy seasonal rains, snowfall, icing, seasonal winds of unusual severity, frequent or seasonal fogs, or exceptionally high or low temperatures are typical to a coastal area, work time estimates should be modified to allow for such conditions.

Good engineering design is based on a careful consideration of pertinent variable relationships and their applications. A temporary or expedient construction design is good if it fulfills its purpose within job limitations. Whenever possible, standard designs are used to save time in design, construction, and maintenance. Standard designs and their accompanying bills of material are the basis for advance procurement of construction materials and equipment. The engineer must fit these designs to the site and adapt them to the existing conditions. Reconnaissance, construction surveys, soil bearing tests, driving of test piles, and perhaps sieve analyses of local sands and gravels are thus prerequisites to the preparation of final design drawings and bills of material. Design of nonstandard structures is usually carried out only if standard designs cannot be adapted.

Field Manual 101-10-1 gives planning factors for approximate materials and man-hour requirements in overall planning and estimating of general and break-bulk cargo port construction. Technical Manuals 5-301 through 5-303 also give data on design, material, and labor requirements for port structures.

PORT CONSTRUCTION

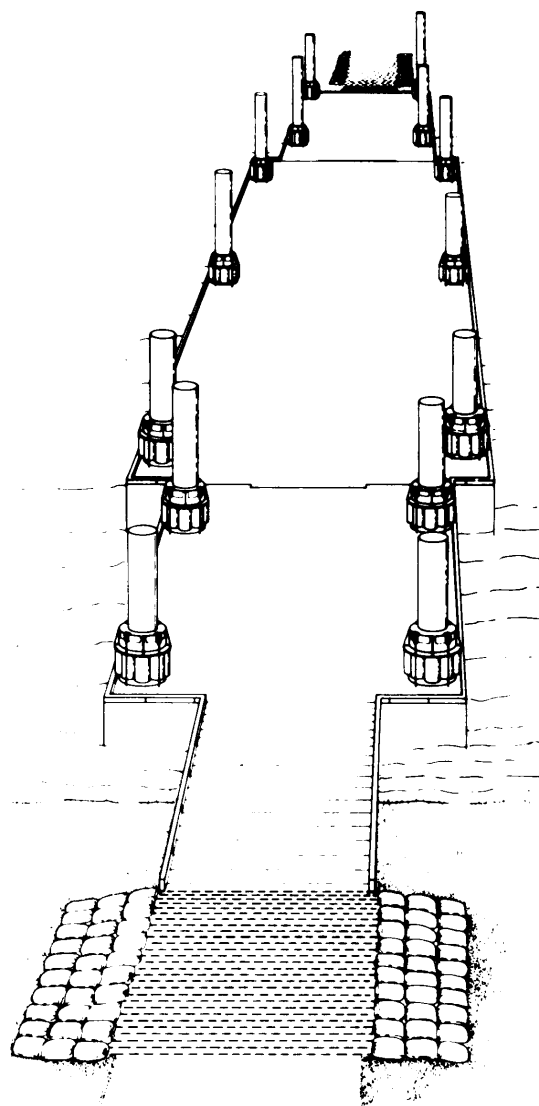
PHASED CONSTRUCTION

Current procedures for port construction in undeveloped areas usually fall under the following phases:

- Ž Phase One, Preliminary. This phase includes all requirements from the arrival of construction units to the beginning of construction of deep-draft wharves. The LOTS operations are conducted during this phase.
- Ž Phase Two, Initial Construction. This phase continues to the point at which the first cargo-ship berth is fully operational, including road and rail connection, water supply and electrical services, and bulk POL handling facilities that can receive liquid fuels direct from oceangoing tankers.
- Ž Phase Three, Completion. This phase ends when all authorized facilities are fully operational.

CONSTRUCTION METHODS

Commercial records indicate that at least 9 months are required for a skilled construction crew of 30 to construct a modern (approximately 80 by 1,000 feet) steel or concrete pile wharf by conventional (cast-in-place and/or on-site job erection) methods. This time requirement, even allowing for larger construction crews, indicates that neither steel nor concrete pile wharves will likely be built by conventional methods in the future. Recent studies indicate that although steel and concrete will be the most common building materials in new military port construction, their use will probably be limited to new, unconventional construction methods.



DELONG PIER

Steel wharves or piers

The use of steel in future military port construction is expected to occur mainly in the construction of expedient container ports with large self-elevating, self-propelled, spud-type barge pier units. These can be put into service in relatively short periods of time.

These structures have been used extensively in the oil exploration industry. Their recommended use in expedient port construction is therefore based not only on concepts but also on actual use in situations at least as demanding as those found in modern military operations. The newer versions of these barges use truss-type supports rather than caissons. They may be elevated at a much faster rate (50 feet per hour) and are more relocatable than the older DeLong type barges. This capability may limit the planning for construction and expansion of future ports to getting the individual components to the job site.

Concrete wharves or piers

Commercial port engineers have prepared and are continuing to prepare designs for precast concrete pier pilings, caps, decks, and curbs. These techniques should reduce conventional concrete port construction time requirements considerably.

CONSTRUCTION MATERIALS

Materials demanded for port construction are often quite specialized or unique. Class IV supplies include all construction materials and installed equipment. Following initial occupation, supplies received from the continental United States (CONUS) will, for a certain period of time, follow an automatic rate prescribed by the Department of the Army. At a later stage, the basis of supply changes from automatic shipment to requisition. Theater requisitions for engineer construction materials must take careful account of project requirements for special large-scale operations. Issues from stocks are based on

the requirements for the particular work on which the requisitioning unit is engaged. Critical items of Class IV supply may be issued under policies approved by the G-4; uncontrolled items are issued on call.

The task of providing engineer construction supplies for a modern Army from CONUS, especially in an overseas theater, is so large, so complex, and so costly, that every effort must be made to simplify it through the use of local procurement. A continuous inventory of stocks of construction materials and equipment available locally is maintained by the unit supply officer. Class IV supplies suitable for local procurement may include: lumber, cement, structural steel, sand, gravel, rock, plumbing and electrical supplies, hardware, and paint.

SUPPORT FACILITIES

A large amount of construction effort goes into building port support facilities. If a port is located in an area where there is an adequate rail or roadway network, cargo-handling (break-bulk or container) operations will be more efficient when there are like connectors on the wharves. Engineer units are responsible for the construction of rail and roadway facilities required by the port. Plans are worked out in coordination with Transportation Corps requirements, as discussed in Chapter 6.

Designs currently being recommended to the Army for future expedient military container port construction generally specify tractor-trailers to transport the individual containers from the wharves. The wharf must be of sufficient strength (capable of supporting up to 1,000 pounds per square foot of live loads) and width (usually 80 to 100 feet) to accommodate fully loaded TOE tractor-trailers and be constructed to an elevation from which suitable connections can be made to existing or planned roadway networks.

Other on-shore construction requirements include—

- Ž Potable and impotable water supply for ships docked/moored in the port as well as the port itself.
- Ž Electric power supply and distribution which may require overhead and underground systems.
- Ž Fire fighting facilities and special systems as needed, such as special facilities for POL terminals.

Suitable water depths must be maintained at ports. According to FM 101-10-1, a minimum low tide water depth of about 33 feet should be used for planning purposes because it will accommodate virtually all deep-draft vessels. However, the recent trend toward containerization and the use of large tankers with over 50,000 hundredweight capacities indicate that some future military ports should be planned with minimum water depths of 40 to 50 feet. The planned construction of wharves in water depths several feet less than desired may also be justified where—

- Ž It is established that the required depth can be obtained by dredging, that such dredging is practical as part of the construction project, and that it can be performed without endangering the in-place wharf structure.
- Ž Short-term use is anticipated, thus making lighterage more feasible than dredging or wharf relocation.

The actual minimum water depths of new wharf construction are dictated by the wharf's intended use (POL wharf, container wharf, lighter wharf). These depths are determined and given in the operation order.

Dredging may be required to establish and maintain required depths. Experience gained during World War II and in Vietnam indicates that there are a number of specific problems associated with dredging projects in a Theater of Operations. Transportation of dredges to the Theater of Operations can be difficult. Hopper dredges and sidecasting dredges are the only ones that are seagoing. Other dredges must either be towed to the site or assembled from components transported aboard cargo ships.

It is also difficult to secure dredges within the Theater of Operations. The routine patterns followed by dredges greatly limit the effectiveness of any passive defensive measures. Pipeline dredges are virtually stationary targets. The availability of dredges and crews for use in early stages of deployment in a Theater of Operations is a major problem. The Army at the present has no trained military dredge crews or portable dredges suitable for use in a Theater of Operations.

Sweeping, covered in detail in TM 5-235, is a method of locating pinnacles or other obstructions which exist in navigation areas above the depth limits required by the draft of the largest ships to use the area. Sweeping is always used as a final check after dredging operations.

REPAIR AND MAINTENANCE

Repair and maintenance involves the correction of critical defects to restore damaged facilities to satisfactory use. Repair and maintenance of conventional and expedient construction could include emergency repair, major repair, rehabilitation of breakwater structures, and expedients.

EMERGENCY REPAIR

Emergency repair is work done to repair storm, accident, or other damage to prevent additional losses and larger repairs. Emergency repairs include—

- Ž Repairs to breached breakwaters to prevent further damage to harbor installations.
- Ž Repairs of wharf damage caused by ship or storm damage or enemy action restore structural strength.
- Ž Dumping rock to control foundation scour or breach erosion.

MAJOR REPAIR

Major repair is significant replacement work that is unlikely to recur, such as—

- Ž Replacing wharf decks.
- Ž Resurfacing access roads and earth-filled quays.
- Ž Replacing wharf bracings and anchorages which have been destroyed by decay or erosion.
- Ž Replacing entire spud barge pier, spud, or other major barge pier accessories.

REHABILITATION OF BREAKWATER STRUCTURES

The repair of breakwaters and similar structures is required to protect the characteristics of a harbor. Breached breakwater structures are repaired by dumping rock of sizes suitable for use in mounds.

EXPEDIENTS

The use of expedient methods should be encouraged during limited port operations while major repair and rehabilitation go forward. A number of possible measures to speed repairs are listed below.

- Ž Launches or tugboats with a line to the shore may be used for various hauling and hoisting functions in construction work at the waterfront.
- Ž A floating crane may be improvised by erecting a derrick or installing a crawler- or truck-mounted crane on a regular barge, LCM, a barge of pontoon cubes, or a barge fabricated for military floating bridge units.
- Ž Rafts for pile-bent bracing operations may be fabricated from oil drums, heavy timbers, spare piles, or local material.
- Ž Floating dry docks for small craft may be improvised from Navy pontoons.
- Ž Light barges, floating wharf approaches, and small floating wharves may be improvised from steel oil drums.
- Ž Diagonal flooring laid over existing decking strengthens a structure by distributing the load over more stringers.
- Ž The decking may be removed for adding stringers, or smaller stringers may be placed on the pile cap between existing stringers from beneath the decking and wedged tight against the deck.
- Ž If the wharf can support the weight of the pile driver, several floor planks can be taken up and the piles driven through the hole. New pile bents are capped and wedged tight against the stringers.

- Ž A rock or ballast-filled timber crib may be used to replace a gap in a pile wharf structure or to extend the outshore end on the wharf. The timber crib may be built on land, launched by using log rollers, floated into position, and filled with rock or ballast to hold it in place.
- Ž Use standard military floating bridges or Navy pontoons to supplement or temporarily replace damaged causeways.
- Ž Use standard military floating bridges or Navy pontoons to provide access between undamaged sections of off-loading piers.
- Ž If a section of a wharf has been destroyed, the face of the wharf is restored first so that ships may be worked while the area behind the face is being restored.
- Ž The shore end of a pier may be used for lighters or other short vessels while the pier is being extended.
- Ž Part of a solid-fill wharf may be bridged using standard or nonstandard fixed bridging.
- Ž If a slip is filled with rubble so that ships cannot be brought to the face of the wharf, it may be possible to fend them off with camels, barges, or other devices so that they will be retained in deep water for unloading. Alternatively, it may be possible to use standard trestles, fixed bridging, and assembled Navy pontoons to extend the width of the pier.
- Ž The hull of a capsized or sunken vessel may be used as the substructure for a pier.
- Ž The shore end of a causeway constructed from Navy pontoon cubes may be anchored onshore by excavating a section of beach, floating the pontoons into the temporary inlet thus made, and then backfilling to provide a solid anchorage.